Protecting the Forest

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FOREST MANAGEMENT
CORRESPONDENCE COURSE

UNIT 4

Purposes

- Understand the fundamental processes involved in the impact of fire, disease, and insects on forest resources.
- Identify fire risks and hazards to permit direct action in minimizing the probability of fire losses.
- Identify the early symptoms of tree diseases and insect outbreaks.
- Identify sources of professional advice and technical assistance available to help you deal with fire, insect, and disease problems.

The Need for Understanding Basic Problems and Processes

As an owner of private nonindustrial forestland, you should be aware of the possible damages and financial losses that can be caused by fire, insects, and disease. The safety of your property is determined by its specific characteristics (size; location; species, ages, and sizes of trees; etc.) and by the type and level of protection services you make use of (fire suppression, insect and disease detection and control).

If you live on or near your forest tract you may be able to watch for danger signals and take direct action to prevent or minimize losses. As an owner, you should know about the basic problems and processes of forest protection. Then you can analyze the local situation and work with the people who provide the technical services that can help you reduce losses. For example, you should know who fights fires that start on or near your property. And you should know who watches for insect or disease outbreaks and who can give you technical advice when a problem develops on your land.

Fire Management

Fire management involves the prevention and control of wildfire and the use of prescribed fire. Both fire control and use are based on an understanding of how fires behave and how they affect the environment and property values. The catastrophic North American forest fires of the 1800s killed hundreds of people, destroyed entire communities, and discouraged interest in forest management. These disasters stimulated federal and state governmental action to control fire. In the last 80 years these efforts have grown from crude and ineffective attempts into the large and effective forest fire protection systems we have today. These efforts, started by foresters, woodsmen, and volunteers using hand tools and practical experience, have evolved into sophisticated, highly mechanized fire control operations. As this field has developed, research has added a new dimension of understanding and has added new tools and tactics.

FIRE BEHAVIOR

The behavior of any wildland fire is determined by the principles of physics and chemistry. Fire in forest fuels is rapid oxidation with the release of heat energy and light. If combustible material is raised to its kindling temperature by the application of heat in the presence of oxygen, it will lose moisture and release combustible gases that ignite and produce flames. Woody fuels, especially those larger than one inch in diameter, often will continue to burn as glowing charcoal after flames disappear. Wildland fire behavior is influenced by fuel, weather, and topography.

Effect of Fuel

Surface fuels (leaf litter, dead grasses, logging slash, etc.) vary in amount (tons per acre), arrangement (depth, continuity), fuel energy, and moisture content. Large areas of continuous dry flammable material burn hot and fast, producing high intensity fires that are dangerous to attack and difficult to control.

Effect of Weather

Weather influences fire behavior in two primary ways. First, the moisture content of fuels is determined by the nature, amount, and duration of precipitation and the drying periods between storms. Second, wind bends flames and supplies oxygen to the burning fuels. Thus wind speed determines the rate of forward spread of a flame front. Hot, dry, windy days that occur after a period of dry weather are potentially bad fire days, especially during the time of year when most surface fuels are cured (after frost in the fall, before green up in the

spring). Fires that occur after 10 or more days without rain followed by temperatures in the 70s or higher, with relative humidity under 30 percent and winds more than 20 miles per hour, will spread rapidly.

Effect of Topography

Topography also influences fire behavior. Flame fronts accelerate as they move up steep slopes. They generally slow down as they back into the wind or travel down a slope, unless burning firebrands roll downhill to spread the fire into unburned fuels below. Topography also modifies wind currents; the resulting eddies and shifts influence the direction and rate of fire spread.

FIRE EFFECTS

The direct effects of fire result from the high temperatures, which can kill plant tissues, injure animals, and affect other environmental features. Small trees, especially conifers (pine, spruce, balsam fir) can be ignited and killed almost instantly by surface fires. If heat penetrating the bark raises the cambium temperature to 140° F., it kills these cells. If such temperatures occur only on one side of a tree, a basal fire scar will result. If they occur around the whole stem, the tree will be girdled. Bark sloughs off fire scars and callus tissue forms on the edges of the wound until the scar is covered. Such scars may result in decay and defects that eventually reduce the value of the butt log. Girdled trees usually die in a short time. If merchantable, they should be salvaged before they deteriorate.

Bark thickness, tree size and form, sprouting capacity, and other characteristics that vary from species to species determine whether a brief exposure to high temperature flames girdles or scars a tree. The discoloration of dead cambium tissue can be noted a few days after a fire. Sampling charred stems with an increment borer, knife, or ax can be useful in making salvage and damage claim decisions. Heat injury is greatest on the side of the tree away from the fire, so the first place to check for dead cambium is on that side, a few inches above the litter surface.

The direct effects of fire on woody shrubs or understory plants is similar. The effect on perennial grasses and herbs varies greatly with the season. Most of these plants are safe during the dormant season but are vulnerable when they are growing actively. Perennials regenerate from their roots as well as from seed. Annuals regenerate only from seed.

Most fires have little direct heat inpact on soil, since only a shallow surface layer is heated. Animals usually can escape the flames and heat injury by flying, running, or hiding underground. Nests with eggs and young animals with little mobility sometimes are injured by spring surface fires, and insects that overwinter in surface litter may be killed.

By affecting plant succession and changing species composition, size and density of the vegetation fire can have a significant influence on a property. This influence may persist for decades. Changes in animal populations often occur as the vegetation changes. Vegetative changes may be related to changes in soil properties on recently burned areas where nutrients have been released by the combustion of accumulated litter. The charred, blackened surface often absorbs more heat from the sun and the warm soil produces plant growth faster.

FIRE DANGER RATING

Fire danger is a concept that integrates the major factors that determine whether wildfires start, spread, and do damage and how difficult they are to control. The objective of *fire danger rating* is to combine fuel, weather, and fire cause information in an index that predicts how tough the fire protection task will be on a given day.

A national fire danger rating system (NFDRS) has been used in the United States since 1973. By selecting a fuel type that fits the local situation and using local daily weather observations, NFDRS provides a burning index that predicts how fast a fire will spread and how hot it will be. NFDRS estimates the probability of fire occurrence by combining lightning and human activity related to fire starts with fine fuel moisture content.

You should know who takes local weather observations and maintains fire danger records in your area. Having such information is especially important when long periods without rain combine with high midday temperatures, low relative humidity, and high wind speeds. Special efforts can be used under these conditions to reduce risk by closing roads, by warning people not to smoke in the woods, or by cancelling burning permits. Early detection of smoke can be achieved by adding flights or extending the hours of lookouts. Crews and equipment can be placed on alert and extra firefighters can be placed on standby.

Fire Prevention

Firefighters agree that the easiest fire to stop is the one that doesn't start. Not all fires can be prevented, but a concerted effort can reduce the number of wildfires and the related costs of suppression and damage. The first step is to learn how fires start. The second step requires changing the behavior of the people involved.

Fire causes are reported by the crews that handle initial attack in the field. Seven standard fire cause categories or risk classes are used:

1) *Lightning* — result from long strikes, which travel from clouds to the ground, especially those associated with dry lightning storms.
2) *Campfire* — result from cooking or warming fires that escape.
3) *Smoking* — result from use of matches, lighters, cigarettes, pipes, and other devices or materials used by smokers.
4) *Debris burning* — result from use of fire to dispose of combustible trash, garbage, crop residues, logging slash, or other material. Land clearing, site preparation, and other prescribed burns are included in this class.
5) *Incendiary* — result from deliberate arson on lands that are not owned or leased by the arsonist.
6) *Equipment use* — result from operation of all mechanical devices and equipment other than railroads.
7) *Railroad* — result from operation of railroad equipment or maintenance of railroad right of way.
8) *Children* — result from the activities of children under 12 years of age. This category includes accidental and deliberate starts.
9) *Miscellaneous* — result from activities or incidents that do not fall into the other eight classes.

Since causes are reported for all fires that require suppression, it is possible to analyze fire causes for a given fire protection area and to identify which causes are most important in terms of proportion of all reported fires or of area burned. This analysis also can identify the causes that start fires during extreme fire danger periods, which can sharpen the focus of fire prevention efforts.

All Americans are familiar with Smokey the Bear, the symbol of fire prevention. Media messages, billboards, posters, and other devices have been used to increase public awareness of the need to prevent wildfires. This general approach reaches large numbers of people, but simple repetitive warnings do not provide the specific information necessary to change the behavior of some people who are responsible for fire starts.

To supplement this general approach, specific education efforts need to be conducted. Campers can be educated to use cookstoves, or they can be shown how to mix water and soil with campfire ashes until they are cold to the touch or "dead out." Smokers can learn how to dispose of their smoking materials safely. Debris burners can learn how to use an incinerator or when and how to burn safely. Equipment users can learn to operate and maintain their equipment to minimize accidental fire starts. Railroad workers can learn to maintain their locomotives to reduce sparks or burning firebrand escapes and to avoid starting fires when clearing right of way or disposing of old ties. Children can learn the dangers of playing with matches.

Check with the organization that provides fire suppression service to your property and find out what the important causes of fire have been in recent years in your locality. With this information, you may want to contact individually your neighbors and people who visit your property to be sure they know how to avoid starting a fire. By meeting in a friendly way with some of the neighboring children, you may be able to enlist their help in protecting your property.

PRESUPPRESSION

Whatever can be done before a fire starts to make its control easier is called presuppression. This includes the detection systems of airpatrols and lookout towers. It also includes building, equipping, and staffing the fire protection organization. Fire management planning done by experienced fire specialists starts with a fire cause analysis. Specialists review the record of each administrative unit to rate effectiveness and to find places for improvement. For example, analysis of *elapsed time* records (from start of fire until spread is stopped) may show that *discovery time* (from start of fire until it is detected and located) may be excessive. A better detection system is needed to correct such a situation.

If *travel time* (time required for the initial attack force to reach the fire) is too long, the transportation system may need improvement. If *control time* (from arrival of the firefighters until spread is stopped) is too long, more people and equipment may have to be sent on initial attack. These examples illustrate what the fire protection organization can do to increase its effectiveness. Your responsibilities and opportunities as a landowner are discussed below.

SUPPRESSION

Firefighting — the suppression of wildfire — includes the use of a wide variety of tools and tactics. Since a fire can't burn without fuel, oxygen, and heat, firefighting methods are designed to keep the fire from reaching new fuel, to smother the flames and cut off oxygen, or to cool the burning fuels. A fireline dug to mineral soil with hand tools (shovel, rake, or hoe) or with machinery (tractor or plow, bulldozer or roadgrader) prevents a fire from reaching more fuel. Dirt thrown by shovel, wet sacks, a green pine branch, or retardant delivered by pumper truck or air tanker can smother flames and cut off the oxygen supply. Water applied by backpack pumper or a hose from a pumper truck cools the burning fuels and prevents rekindling.

Fire suppression tactics must be adapted to terrain, fuel, and weather conditions. If the fire spread rate, flame length, and terrain permit safe work on the burning fuels, direct attack is used. This means that the perimeter or expanding edge is extinguished to control the spread. When firefighters arrive at a fire, they first size up the situation. They determine how the fire is spreading, what special values need protection, and how they can quickly, efficiently, and safely stop the spread and put the fire out. In most cases this involves direct attack. The initial effort is applied at the head of the fire, which is advancing most rapidly. Once the head has been contained the flanks and tail are controlled.

If a fire is too hot for direct attack on the head, a flanking attack can be used. This tactic allows the crew to move down the flanks and extinguish flames by spraying water on the burning fuels as they move. By moving faster than the head, they catch up to it and pinch it off. This tactic also allows firefighters to work with the wind at their backs. They avoid the discomfort and danger of working in heavy smoke, high flames, and intense heat.

When a fire is too hot, is spreading too fast, or terrain does not permit direct attack (for example, on a cattail marsh with soft wet ground unsafe for vehicles or for people carrying backpack pumps), indirect attack is used. The firefighters prepare a firebreak or select an existing feature (road, trail, stream, etc.) some distance ahead of the fire and backfire (burn into the wind) to consume the surface fuels between the line and the advancing fire. Indirect attack requires knowledge of fire behavior and skill in locating and constructing the line and timing the ignition of the backfire. *It should be attempted only by experienced firefighters.*

Fire suppression requires physical stamina as well as a knowledge of fire behavior and skill in the use of tools and tactics. People who have health problems or people who are not in excellent physical condition should avoid the risks involved. An entire crew can be distracted from firefighting when one member collapses with fatigue or an injury caused by working with unfamiliar tools under stressful conditions.

Prescribed Burning

Fire can be used in some forest management programs to prepare planting sites, to reduce fire hazards such as logging slash, and to improve some wildlife habitats. As a landowner, you or your agent must assume legal and financial responsibility for the consequences if the fire escapes, so the practice is limited. There is a risk of losing a fire and paying hundreds or thousands of dollars for suppression costs. Large civil damage claims for the impact of the escaped fire on adjacent property values can result. If you are considering using prescribed burning, you must obtain a burning permit from a local fire protection unit. *Ask the same fire protection unit for advice and assistance in planning and conducting the burn.*

WHAT YOU CAN DO AS A LANDOWNER

Fire Prevention

The first and most obvious way you can reduce the probability of loss due to fire is to avoid starting fires accidentally. Show smokers who work on or visit your property how to dispose of cold matches and dead cigarette butts properly.

Be sure any trash burning is done in safe incinerators or under safe weather conditions. Maintain your machinery and operate it carefully to avoid fires started by hot exhausts, spilled fuel, or combustible peat dust on hot manifolds. If you have tall trees close enough to a power line to break wires if they fall, remove them. Be sure all stove pipes and chimneys have spark arresters and clean them regularly to avoid chimney fires. For other suggestions, ask your local fire warden, district forester, or fire department.

Presuppression

Design and maintain the road and trail system on your property to permit fast access for initial attack vehicles. Loop roads that ensure escape routes in case of wind shifts or other extreme fire behavior problems will encourage aggressive attack. Disked or plowed mineral soil firebreaks will slow the spread of fire and provide a starting point for backfiring.

Some fire trucks cannot travel on narrow, rough, or soft sand firebreaks. A well packed truck trail with mowed edges seeded to high moisture vegetation such as clover may be more useful for firefighting and for wildlife values. When a road or trail crosses a low wet area, a little extra work can produce a water hole where tanks can be filled quickly.

You can store some firefighting tools on your property ready for emergency use by you, employees, or visitors. One backpack pump, a shovel, and a rake plus some burlap sacks and a bucket or two may make the difference between keeping a fire small until help arrives or letting it gain size and momentum without interference.

Suppression

If you are present when a fire starts on your property or on adjacent land, you may be able to assist in controlling the fire. Meeting the initial attack crew when they arrive and showing them the quickest way to the fire can save important minutes. This possibility, of course, assumes that you have given your local fire protection unit keys to any locked gates plus a map of the road and trail system on your property. If you have no firefighting experience, you may want to attend a training session conducted by the local fire protection unit to become familiar with tools and tactics. Another way to acquire this experience is to volunteer and work with the fire crews when they are handling a fire in the vicinity. Observing experienced people in action provides a basis for effort should an emergency occur.

As mentioned earlier, any person who attempts to attack a fire must recognize the potential danger involved. Heavy exertion under the emotional stress of a threatening fire situation can lead to exhaustion or worse. Each person has to understand and accept the limits that age, health, or physical condition place on his ability to fight fire. A person who cannot walk into the woods with a 55-pound five-gallon backpack pump on his back may be able to patrol a smoldering fire perimeter and cool down any flames that reappear by shoveling dirt on them.

In some states landowners can purchase forest fire insurance. Where fire protection service is effective and the probability of loss is low, insurance may be a reasonable way to avoid a financial disaster. Unfortunately, in areas where fires are common and the probability of loss is great, the cost of insurance usually is very high, or insurance is unavailable.

For the reasons explained earlier, most of the fire protection job will be done by professionals. There are some things you can do to reduce the risk and to cooperate with the people who protect your property. By being informed about the local situation and by talking to the people who provide fire protection service, you should be able to minimize the danger of substantial fire losses. Be sure to list the telephone number of your local fire protection service on your forest management plan (unit 1).

Protecting the Forest From Insects and Diseases

Each year, insect and disease agents account for 62 percent of the trees killed in Minnesota forests. This loss and the reduced growth due to these pests amount to more than half the total annual growth in Minnesota forests and nearly twice the total annual harvest.

Direct control practices (pesticide spraying, early harvests, precommercial thinnings, salvage, etc.) are expensive. They also may be limited in their ability to control pest outbreaks. Normally, forest landowners can use direct control techniques only for high value crops (Christmas trees, nurseries, and seed orchards) or when no other alternative exists. Therefore, preventive management techniques must be used to reduce the necessity for direct control.

Integrated pest management (IPM) is a strategy for pest control. It incorporates all available mechanisms for influencing the occurrence, severity, spread, persistence, and frequency of pest problems. IPM is based on an understanding of the tree species, its pest problem, the site, and the local environmental conditions to help make the right forest management decisions. What makes IPM so important is that pest problems very often are the direct result of the management practices used. Prevention, therefore, is not a possible tool but a management necessity.

Insect and disease problems must be considered in any attempt to avoid or reduce the need for direct control measures in the future. Pest problems often restrict management options. Individual pest problems influence forest management decisions from regeneration to harvest. The most crucial point for addressing preventive pest management is during regeneration. Decisions made at this point set the stage for the next 50-100 years. The primary thrust of IPM is making sound forest management decisions, beginning before regeneration and building until successful harvest. A sound management program increases yields and quality and the final value at harvest.

RECOGNIZING RISKS AND HAZARDS: PREPLANNING

Specific insect and disease problems often occur repeatedly in a certain area of the state. This can be the result of local climate, species distribution and vigor, or site conditions that favor insect or disease growth and development. These repeated problem areas are an important consideration in managing your forestland.

The Foresty Division of the Department of Natural Resources annually surveys and maintains records on pest problems of forestlands. This information is available on request.

Table 1 lists repeated major forest pest activity by area of the state. Consider these problem areas as you develop your forest management plan regeneration activities. The presence of persistent pests may influence species planted, regeneration, site preparation, or stand maintenance activities.

You should survey your stands periodically when a repeated pest problem occurs in your area. The earlier a

Table 1. Geographic location of repeated major forest pest problems in Minnesota

Pest	Species	Area
Spruce budworm	Balsam fir, white spruce	Northeastern Minnesota
White pine blister rust	White pine	Northern Minnesota (most severe area of occurrence)
White pine weevil	White pine	Scattered locations
Jack pine budworm	Jack pine	North central and northwestern Minnesota
Pine tussock moth	Jack pine	East central Minnesota
Yellowheaded spruce sawfly	White spruce	Scattered in northern Minnesota
Dwarf mistletoe	Black spruce	Throughout black spruce range
Forest tent caterpillar	Aspen	Northern Minnesota (primarily the northeast)
Hypoxylon canker	Aspen	Statewide
White rot	Aspen	Statewide
Oak wilt	Oak	Southern Minnesota
Dutch elm disease	Elm	Statewide

Table 2. Major insect and disease problems associated with individual species in Minnesota

Host	Problem
White pine	White pine weevil, white pine blister rust
Jack pine	Jack pine budworm, bark beetles, pine tussock moth
Red pine	Saratoga spittlebug, bark beetles, diplodia tip blight
White spruce	Yellowheaded spruce sawfly, root rots, spruce budworm
Black spruce	Dwarf mistletoe
Balsam fir	Spruce budworm
Oak	Oak wilt, armellaria root rot, two-line chestnut borer
Maple	Eutypella canker
Birch	Bronze birch borer, birch decline
Elm	Dutch elm disease
Aspen	Hypoxylon canker, white (phellinus) rot, forest tent caterpillar
Black walnut	Fusarium canker, bacterial blight
Butternut	Butternut decline

problem is detected, the easier it is to control. Preventive control measures in established stands can be a significant aid in reducing potential losses. These measures would be practices such as thinning and pruning, which help improve stand vigor and therefore increase resistance to pest activity.

Individual tree species may have pest problems that greatly restrict how they can be managed. Several tree species in Minnesota have important pest problems; a list of the most important problems appears in table 2.

These problems must be addressed in managing each species if heavy losses within or complete failure of the stand is to be avoided. Specific information on pest management methods is available in the DNR materials listed at the end of the questionnaire.

Table 3. Cultural activities that may increase the risk of insect and disease problems

Category	Activity
Timber harvesting	Leaving standing residual material following final harvest.
	Injuring growing stock during final harvest.
	Failure to harvest completely an area where pest activity has occurred.
	Delaying harvest of mature timber.
	Leaving infested material (trees, slash, or products) on the site.
Site preparation	Failure to recognize past and potential pest problems and their ability to be controlled by site preparation.
	Utilizing site preparation activities that reduce site quality.
	Failure to remove infested material or food source for pests.
	Failure to remove alternate hosts for major insect and disease problems.
Regeneration	Failure to recognize past and potential pest problems and how to address them during regeneration.
	Mismatching the species to the site.
	Planting or regenerating large, continuous areas (greater than 40 acres) to a single tree species.
	Planting insect- or disease-affected seedlings.
	Planting in environmental problem areas such as frost pockets or periodic flooding areas.
	Planting underneath or directly next to older trees of the same or similar species.
	Planting too heavily or too densely.
	Mixing tree species within a stand.
Stand maintenance	Failure to recognize past and potential pest problems and how to address them during stand maintenance.
	Failure to survey stand periodically.
	Injuring growing stock.
	Thinning conifers during the late spring and early summer.
	Pruning during the growing season.
	Failure to remove infested material.
	Allowing stand overcrowding or heavy weed competition.
	Releasing underplanted or understory stands too early.

The effect of cultural activities on the insect and disease problems in a stand begins at the harvest of the original stand and continues through the final cut of the new forest. These considerations can be separated into the major categories of timber harvest, site preparation, regeneration, and stand maintenance. The individual actions that occur within these activity areas influence the occurrence and severity of insect and disease problems, as seen in table 3. A management strategy should be in place before harvesting!

The primary purpose of cultural activities is to promote a vigorous stand, because vigorous stands are less susceptible to pest attacks and injury. The hazards of planting in

environmental problem areas is highlighted under the regeneration category in table 3. Frost pockets, periodic flood sites, and drought sites are problem areas that require proper species choices and maintenance.

The occurrence and severity of insect and disease problems can be linked to broad climatic and individual microclimatic conditions. Examples of this are oak wilt and white pine blister rust. Oak wilt historically does not occur in the northern half of Minnesota (see table 1). White pine blister rust severity can be broken down by hazard zones that range from severe in northeastern Minnesota to slight in southern Minnesota. Severity also is affected by local site conditions such as topography, proximity to water, and aspect. Insect problems also are affected in their occurrence and severity by broad and local environmental conditions.

RECOGNIZING DAMAGE AND SEVERITY

The complexity of recognizing and diagnosing pests is increased by the type of injury that can occur. There are four causes of forest injuries: insects, disease, animals (including humans), and the environment. The symptoms that occur within trees as a result of a variety of different pest attacks can be identical at times. Determining the cause of pest problems requires the ability to separate symptoms according to the key factors that characterize them. These keys often are visible signs or evidence of the pest involved. Characteristic patterns of injury or damage also can be important keys.

COLLECTING INFORMATION

A logical series of observations is necessary in diagnosing insect and disease problems in the field. The four steps necessary in collecting pertinent information are described below.

1) Distribution and location
   - Determine the distribution of the problem within the stand (including tree numbers affected, the pattern of the spread, or both).
   - Determine what tree species are affected (how many species are affected).
   - Determine whether the problem occurs consistently in one type of location (along the edge of a stand, on a slope, etc.).
   - Determine what type of site conditions occur in the affected area.

2) History of the problem
   - Determine whether it has occurred before.
   - Determine when it was first noticed.
   - Determine where it started in the stand.
   - Determine how fast it is spreading.

3) History of the site
   - Determine the recent environmental conditions.
   - Determine whether any severe climatic conditions have occurred.
   - Determine what cultural practices have been conducted recently on the site or nearby.
   - Determine what the area was used for prior to the establishment of the present forest.

4) Examination of individual plants
   - Determine what the symptoms are.
   - Determine where they are located on the trees.
   - Determine how numerous they are and how they are distributed.
   - Determine whether there are any signs of the pest or pest activity present (insects, mushrooms, animals, holes, sap flow, feeding areas, shed skins, etc.).

This information will form the basis for diagnosing the cause of the injury, deciding on its severity, and choosing a control strategy. It also will be needed by pest specialists when they are contacted for assistance in dealing with the pest problem.

SAMPLING

It often is necessary to collect samples for diagnosis by specialists when they are unable to make field visits. When collecting samples in the field, you must differentiate between symptoms and signs of the pest problem. Symptoms generally are the response of a tree to pest attack. The major categories for symptom expression are defoliation, wilting, reduced growth, distorted growth, discolored tissue, sap flow, and death of affected tissues.

These symptoms may occur individually or in combination on leaves, twigs, branches, or stems. They can be important indicators of a pest problem, since the pest may not be present in the affected area. Similar symptoms also can be caused by a wide variety of pests, so you must look beyond symptoms and search for direct evidence or signs of pest activity. These signs vary for the type of pest (insect, disease, animal, or environmental) that has caused the injury.

Signs of Forest Insects

Insects are the most numerous form of life on this planet. For every tree in existence, there are insects with the ability to attack it in every life stage from seed to maturity. A large majority of this insect activity is of little consequence. As the number of insects affecting a tree, forest stand, or geographic area increases, however, the potential for damaging or influencing the management of a forest increases. The variety of insects and insect life stages that can affect a forest result in a diverse assortment of injuries to individual trees.

Insects generally are big enough to be visible with the unaided eye. Unfortunately, they may not be present in the same form or be easily viewable when symptoms are noticed. Their feeding process on trees, however, usually is evidenced by visible signs. These signs may be the insect itself (in one of its life stages), entrance or exit holes, feeding evidence on leaves or twigs, sap flow around injury points, gall formation, webbing, shed skins, tunnels in leaves or wood, pupal cases, excretions, and sawdust. Search for such signs in evaluating or sampling for insect activity.

Signs of Forest Diseases

Forest diseases are just as diverse as forest insects, but they can be much more difficult to diagnose. Disease pests are microscopic and the signs of their activity generally are microscopic also. The exception is their fruiting structures. These sometimes are visible and can be fairly large (toadstools, mushrooms, conks).

The major sign to look for in sampling for disease diagnosis is fruiting structures, which, except for mushrooms, generally are pinhead size eruptions on leaves, stems, or bark. Since the signs of disease problems are so scarce, information on the variety of symptoms being displayed by

affected trees must be collected. The patterns that emerge will offer the key needed to begin diagnosing the problem. Symptoms will be of the same type as those for insect injury but will occur in a more restricted pattern.

Signs of Animal Damage

Recognizing animal damage is one area in which the forest manager often can make a better judgment than a specialist who cannot visit the site. The major step in diagnosing animal damage is looking past symptoms. Though the symptoms may be similar to other problems (wilting, discoloration, death), the injury from animal damage usually is readily apparent upon a thorough inspection of individual trees. Feeding or damage patterns and a knowledge of animal behavior are the keys to solving the riddle. Sampling for animal damage seldom is necessary; samples can be worthless without an evaluation of damage patterns. Of course the signs of activity — droppings, hair or feathers, tracks, teeth prints — may provide conclusive proof.

Signs of Environmental Injury

Environmental injury in forest stands can be divided into chemical, climatic, or disastrous (fire, floods, lightning, etc.). The primary areas where sampling would be beneficial are those where chemical or air pollution is suspected. If you are dealing with such a problem, collect a good cross-section of symptom expression and as much information as possible on potential causes. The symptoms, once again, may be very similar to other pest problems. The key to diagnosing environmental damage is a knowledge of past and present climatic conditions, cultural practices, and any severe action of nature.

DETERMINING THE SEVERITY OF THE PROBLEM

The damage potential of pest problems depends on the tree species, the individual pest, outbreak characteristics, and current environmental conditions. These characteristics provide the base for estimating damage potential. To determine the severity of a problem, these characteristics must be compared to the management goals for the stand. As a general rule, the importance of pest damage increases as the value of the forest products being produced increases. Thus a landowner who produces trees for black walnut veneer has a different definition of a severe pest problem than one who produces aspen for pulp. Your management goals determine the importance of pest damage as it relates to the product quality you want. The guidelines that follow will assist you in evaluating your forest for insect and disease problems.

GUIDELINES FOR ESTIMATING THE SEVERITY OF PEST OUTBREAKS

Tree Species

1) Deciduous (leaf-bearing) trees seldom are affected severely by defoliation as a result of pest attacks unless attacks occur several times within the same growing season, or two or more years in a row, or during periods of environmental stress.
2) Coniferous (needle-bearing) species can be severely damaged or killed by a single defoliation.
3) Short-needled pines (Scotch and jack pine) are susceptible to a wide assortment of pest problems.
4) Trees are most susceptible to damage when first established and as they approach maturity.

Tree Pests

1) Wilt diseases usually result in tree mortality.
2) Canker diseases that attack or reach the trunk of trees severely damage the quality of a tree and weaken it structurally.
3) Wood rots are the greatest source of volume loss in a forest but seldom cause mortality.
4) Dwarf mistletoe is a serious pest of black spruce forests.
5) Pests that cause defoliation in the spring cause more damage than do those that defoliate trees later in the year.
6) Defoliation by gregarious insects (those that feed in groups) is more severe than is feeding by solitary insects spread throughout a tree.
7) Damage by wood borers results in little growth loss or mortality but is an important cause of reduced wood quality.
8) Cambial feeding insects generally attack stressed trees.
9) Except for a few particular insects (Saratoga spittlebug, pine spittlebug, and white pine bark aphid), sucking insects are of little consequence.
10) Insects with more than one life cycle per year pose a greater hazard for damage.
11) Pests that affect the water transport system of trees generally result in greater damage and mortality.

Outbreak Characteristics

1) The potential for damage increases as the population levels of a pest increase.
2) Steadily increasing pest occurrence over a period of years offers the potential for severe outbreaks under the proper environmental conditions.

Environmental Conditions

1) Trees under stress from drought, old age, overcrowding, wet sites, mechanical damage, and other pest attacks are more susceptible to damage.
2) Pest outbreaks in large areas of single tree species have a greater potential for widespread damage.
3) Trees planted on the edge of their range or off-site are stressed and are more readily affected by pests.

GUIDELINES FOR IDENTIFYING TREE DISEASE SYMPTOMS

Necrosis (Death) of Plant Cells

1) Root rot: disintegration or decay of part or all of the root system of a plant.
2) Basal stem rot: disintegration of the lower part of the stem.
3) Damping off: the rapid death and collapse of very young seedlings in the seedbed or field.
4) Canker: a localized wound or necrotic lesion, often sunken beneath the surface of the stem of a woody plant.
5) Anthracnose: a necrotic and sunken ulcerlike lesion on the stem, leaf, fruit, or flower of the host plant.
6) Leaf spots: localized lesions on host leaves consisting of dead and collapsed cells.
7) Scab: localized lesions on host fruit, leaves, tubers, etc., usually slightly raised or sunken and cracked, giving a scabby appearance.

8) Blight: general and extremely rapid browning of leaves, branches, twigs, and floral organs that results in their death.
9) Soft rots and dry rots: maceration and disintegration of fruits, roots, bulbs, tubers, and fleshy leaves.
10) Wood rots: decay of the internal portions of major branches and stems.

Hypertrophy or Distortion of Plant Growth

1) Galls: enlarged portions of plants; usually filled with fungus mycelium.
2) Witches' broom: profuse upward branching of twigs.
3) Leaf curl and blister: distortion, thickening, and curling of leaves.
4) Stunting: overall reduced growth of plants or plant parts.

Wilt

Usually a generalized secondary symptom in which leaves or shoots lose their turgidity and droop because of a disturbance in the vascular system of the root or the stem.

Rust

A group of fungal diseases that produce a powdery fruiting structure, usually yellow to orange in color, over affected areas on leaves or stems.

Mildew

Chlorotic or necrotic areas on leaves, stems, and fruit; usually covered with whitish mycelium of the fungus.

GUIDELINES FOR IDENTIFYING MAJOR TYPES OF INSECT INJURY

1) Leaf feeding: the actual consumption of leaf tissue.
2) Tissue mining: feeding that occurs on tissues within the centers of leaf, shoot, twig, or root material.
3) Sucking insects: insects that feed by removing fluids directly from leaves, shoots, or twigs.
4) Gall formation: abnormal growth of leaves, shoots, and branches, resulting from insect activity. The abnormal growth usually is a localized increase in growth as a result of reproductive activity.
5) Cambial feeding: feeding that occurs on the actively growing tissues underneath the bark of trees.
6) Wood borers: insects that feed on the woody portions of a tree (primarily the trunk and major branches). They form tunnels as they progress.
7) Root feeding: insects that feed on root tissues. Such feeding usually occurs from the exterior, which directly consumes the tissue.

PEST MANAGEMENT ASSISTANCE

Assistance with pest management is available through two major sources: the University of Minnesota Agricultural Extension Service and the Minnesota Department of Natural Resources (DNR), Forestry Division. The Division of Forestry is charged by state law with responsibility for surveillance and control of fire and forest pests on state and privately owned lands.

The division also maintains a private forest management program for providing assistance to forest landowners. Division foresters have been trained in the basics of pest management and can diagnose most of the problems that occur. They are a primary source for background information on local forest pest problems and are capable of assisting you in developing a sound and economical control strategy. If difficult problems occur, they also have direct contact lines with the regional forest pest specialist.

The extension service provides information and education on forest management techniques to public and private forest managers. Extension specialists can provide up-to-date information and education on sound forest management methods and techniques. The University also maintains diagnostic laboratories in the entomology and plant pathology departments; these laboratories accept samples for analysis. Another role of the extension service is providing recommendations on the chemical control of forest pests through published information or through direct contact with extension staff. This information is used by the Division of Forestry as the basis for recommending control methods to the private landowner.

The protection of forests from insect and disease pests is an area of great opportunity. If the rate of these losses can be reduced by even a small percentage, the statewide results will be significant. The development of sound management programs and preventive control strategies will be the major means of accomplishing any significant reduction in losses.

Addresses of the Department of Natural Resources and the Agricultural Extension Service were listed in unit 1. Contact these sources for further help.

Additional References

The following references are available for loan from county extension offices. Check your local library for further sources of information.

USDA. *A Guide to Common Insects and Diseases of Forest Trees in the Northeastern United States.* 1979. Forest Insect and Disease Management NA-FR-4.

USDA Forest Service. *Forest Interpreters Primer on Fire Management.* 1976. TT-53 (1660/2300).

Wildfire Prevention Handbook. 1980. Outdoor Empire Publishing Co., Seattle, WA.

Glossary

Cambium — A layer of cells beneath the bark of a tree or woody plant that provides for growth.

Conifer — A tree, usually evergreen, with cones and needle-shaped leaves that produces wood known commercially as "softwood."

Deciduous — Trees in which leaves fall off or shed seasonally or at a certain stage of development in the life cycle.

Firebrand — Any source of heat that is capable of igniting wildfire fuels.

Girdle — To encircle the stem of a living tree with cuts that completely sever the bark and cambium for the purpose of killing the tree.

Integrated Pest Management (IPM) — A systematic approach in making decisions in developing pest management schemes.

Microclimate — The atmospheric conditions existing in a small area.

Prescribed Fire — A fire intentionally used to satisfy forest management objectives.

Presuppression — Fire control activities concerned with organizing, training, instructing, and managing the fire control unit.

Private Forest Management (PFM) — The management of privately owned forestland, especially that of individuals.

Regeneration — The process by which a forest is renewed. Seedlings or saplings of any origin.

Rotation — The period of years required to establish and grow timber crops to a specified condition of maturity.

Slash — Branches, bark, tops, and other debris left on the ground after logging.

Suppression — All the work of extinguishing a fire following its detection.

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Forest Management Correspondence Course Questionnaire

(Please fill out and return)

Unit 4 — Protecting the Forest

Name _____

Address _____ County _____

1. An absentee owner of a forested tract should know who takes initial attack action on a fire that starts on or near his property. Who has this responsibility for your property? Where are they located? How many miles are they from the closest access to your land? How many travel minutes are they from your property?

2. Wildfire fuels vary in size, amount, and vegetative origin. Their moisture content is critical in determining when firebrands can start fires. What size fuels are most critical for ignition? Which are present on your property?

3. The national fire danger rating system combines weather and fuel variables to predict fire behavior. It also uses risk (lightning and man-caused) to predict fire starts. What can you do to reduce probability of loss when you know that a very high or extreme fire danger has been predicted?

4. What three risk classes or fire causes have been responsible for most recent fires in the county where your land is located?

5. How are fires detected n the vicinity of your property?

6. What tools do you have for direct attack on an early spring grass fire?

7. When and how would you use indirect attack to control fire?

8. List three actions you could take to prevent fires that might damage your property.

9. Is your land located in an area where repeated major forest pests occur? Yes_____ No_____ If your answer is yes, what pests can be found on your land?

10. What cultural activities used in your forest might increase the risk of insect and disease problems?

11. Describe what you consider to be the most serious insect or disease problem in your forest.

    What is the distribution and location of the problem?

    What is the history of the problem?

    What is the history of the site?

    Describe the signs or symptoms you have found on individual trees.

12. Who provides pest management assistance in your area?

13. Please list any questions you have.

The following materials are available on request. Please check those you would like to receive.

☐ Forestry and IPM (reprint about integrated pest management from *The Ames Forester)*

Forest Insect and Disease Pest Management Guidelines (by forest type). Department of Natural Resources.

☐ Tamarack	☐ White Pine	☐ Spruce-Fir	☐ Central Hardwoods	☐ Paper Birch
☐ White Spruce	☐ Red Pine	☐ Oak	☐ Northern Hardwoods	☐ Black Spruce
☐ Northern White Cedar	☐ Jack Pine	☐ Lowland Hardwoods	☐ Aspen	